

# Geosensing Ship Activity to Estimate Invasive Species Risk

James J. Corbett, Ph.D., P.E.  
Professor, University of Delaware

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# Introduction

- **Motivation:**

- Policy
- Technology
- Risk-based approach

- **Model Overview:**

- Vessel ballast and hull conditions
- Trade routes
- Ecosystem similarity
- Environmental organism profiles (eDNA)

- **Application:**

- Visualization of routes
- Case study designs for prospective changes
- Expanded research collaboration

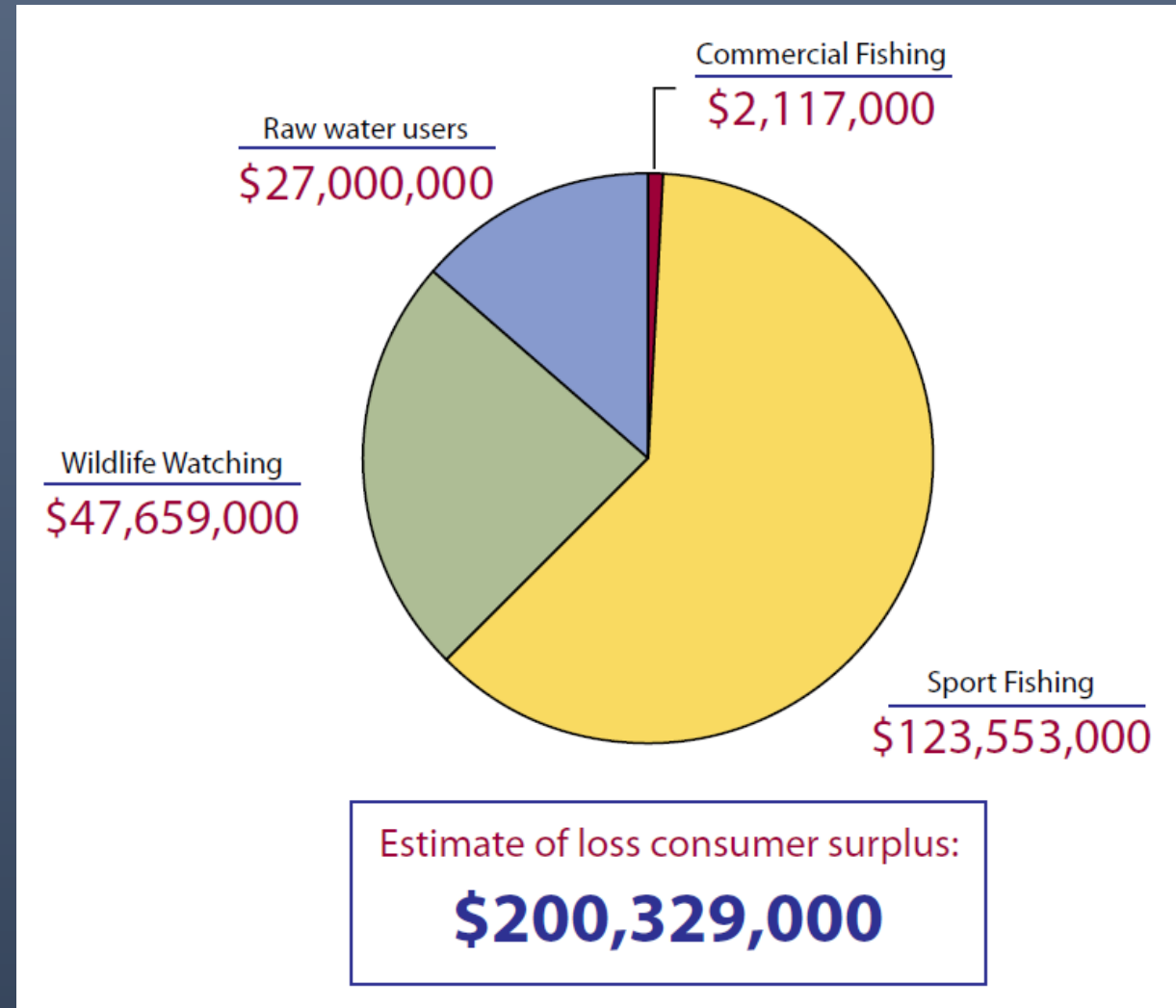
# Ranges and scales of economic impact assessments

- US aquatic invasive species: \$9 B/yr
- US all invasive species: \$120 B/yr
- Worldwide all types: \$1.4 T/yr

Pimental et al, various publications

- Great Lakes: \$200 M/yr

Lodge et al, various publications

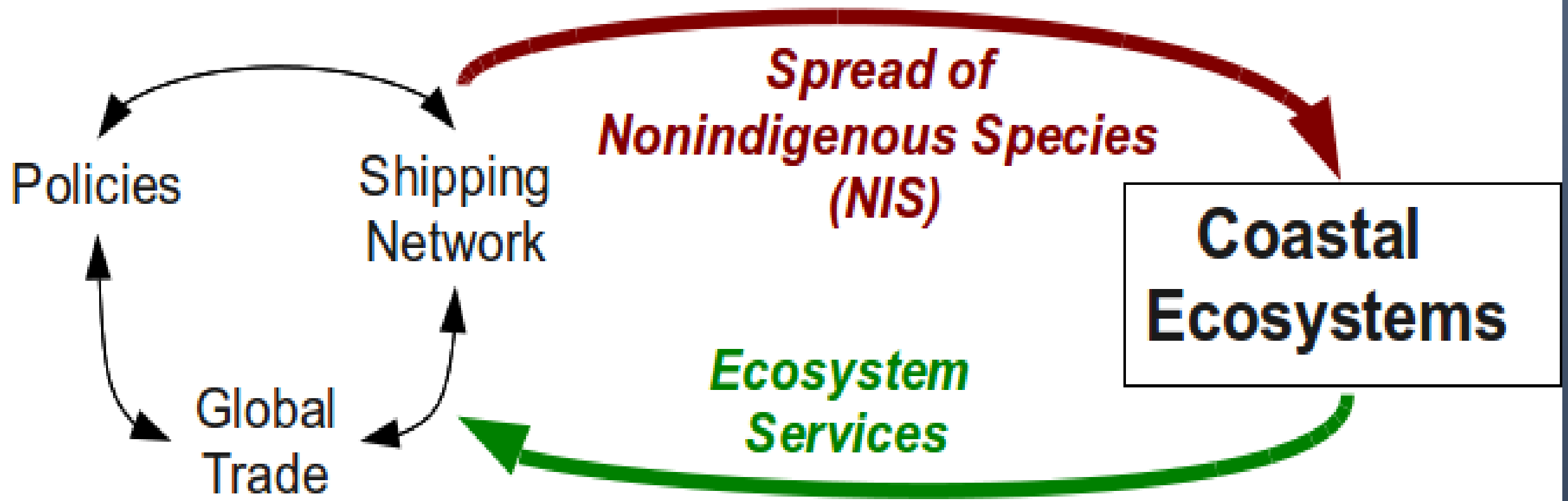


# Motivation

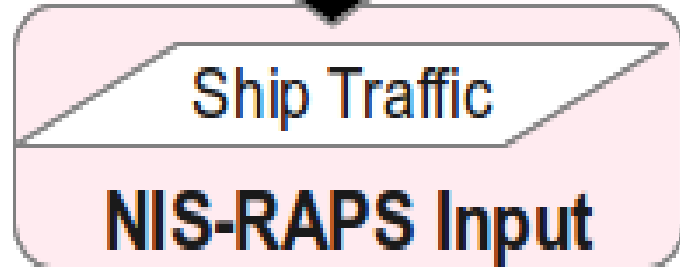
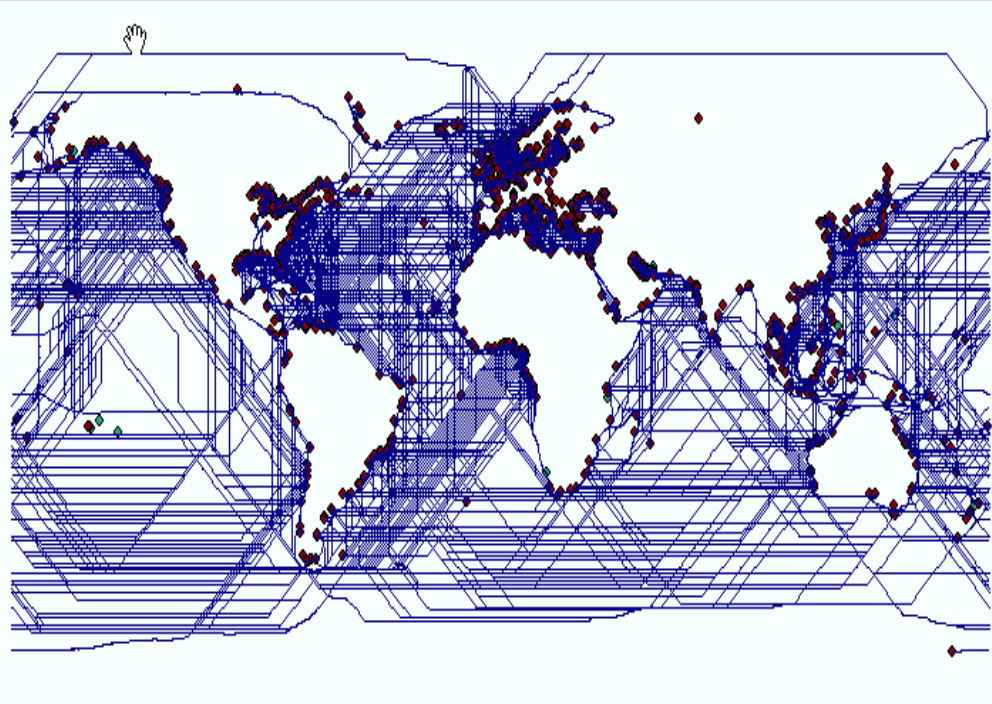
- Policy: IMO Ballast Water Convention, US Clean Water Act
  - IMO BWM nearly in force, set treatment standards, later adopted by US
  - **UPDATE I**: US 2<sup>nd</sup> Circuit Court of Appeals, standards not technology forcing
  - **UPDATE II**: HR 4909 may exempt ballast water discharges from Clean Water Act
- Technology
  - Dozens of treatment systems “certified” under IMO type approval process
  - USCG type approval process – no technologies yet approved (~3 dozen LOIs)
  - New technologies remotely cleans hulls and removes waste to surface
- Risk-based approach
  - Option to employ measures everywhere may be inefficient, ineffective, or both
  - Invasive risk changes with shipping technology, vessel traffic, and trade patterns

# Model Overview

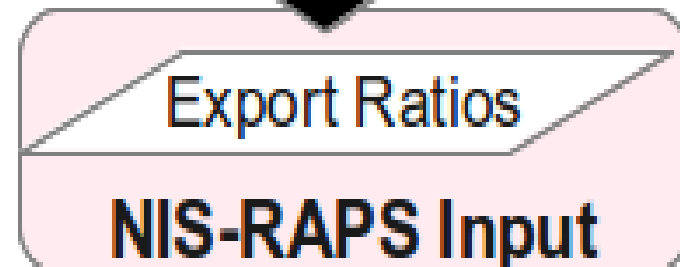
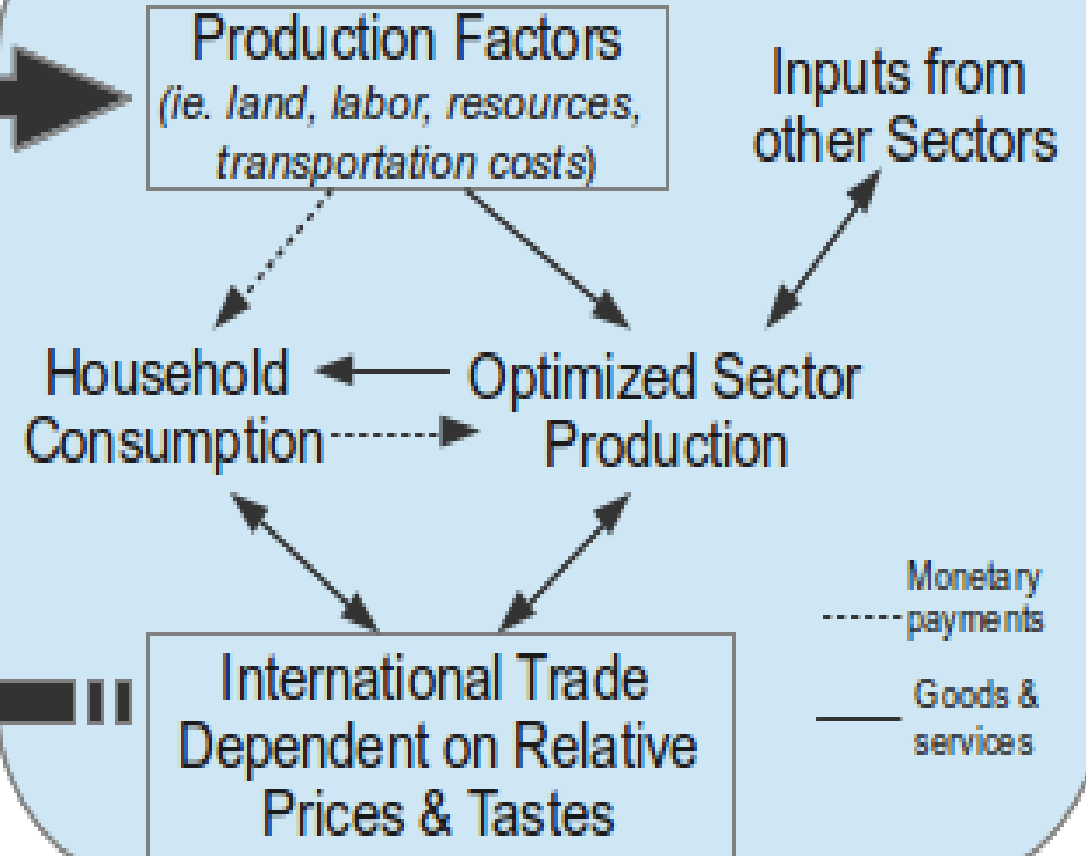
## Human Systems



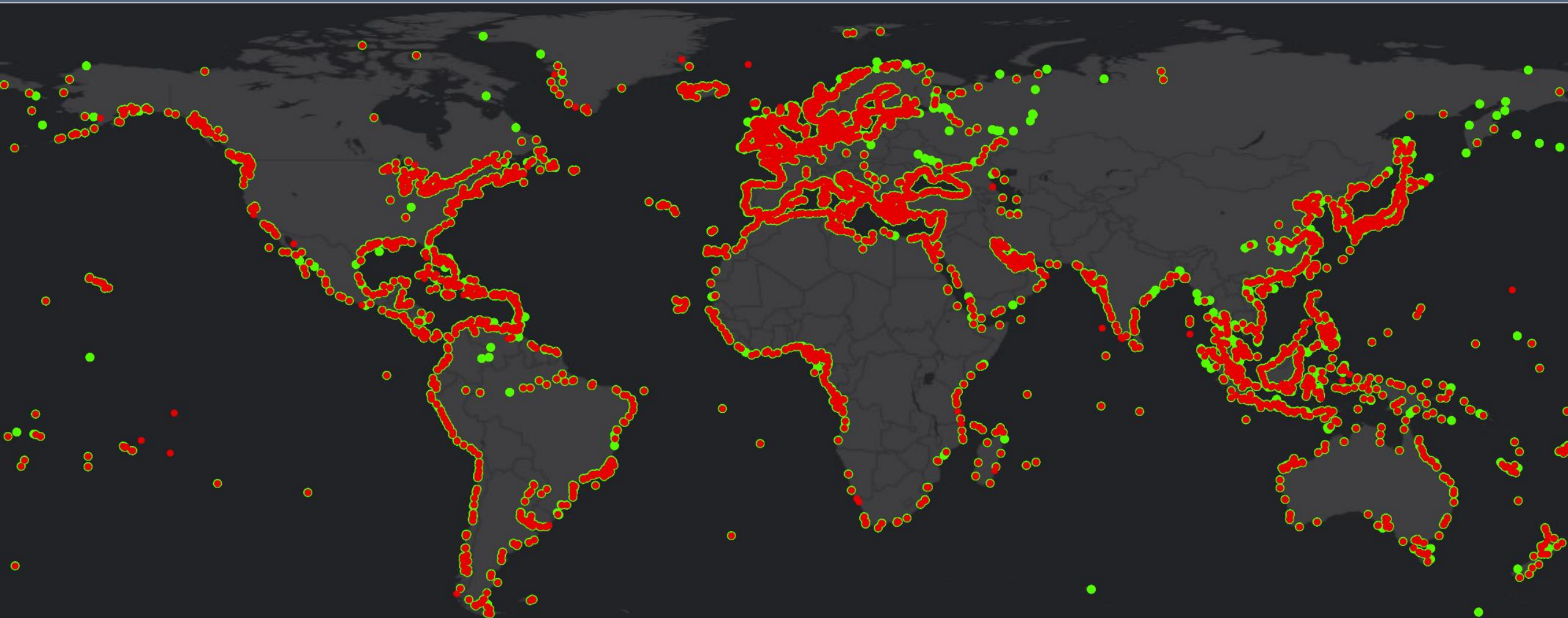
# GIFT Global Freight Transport Model



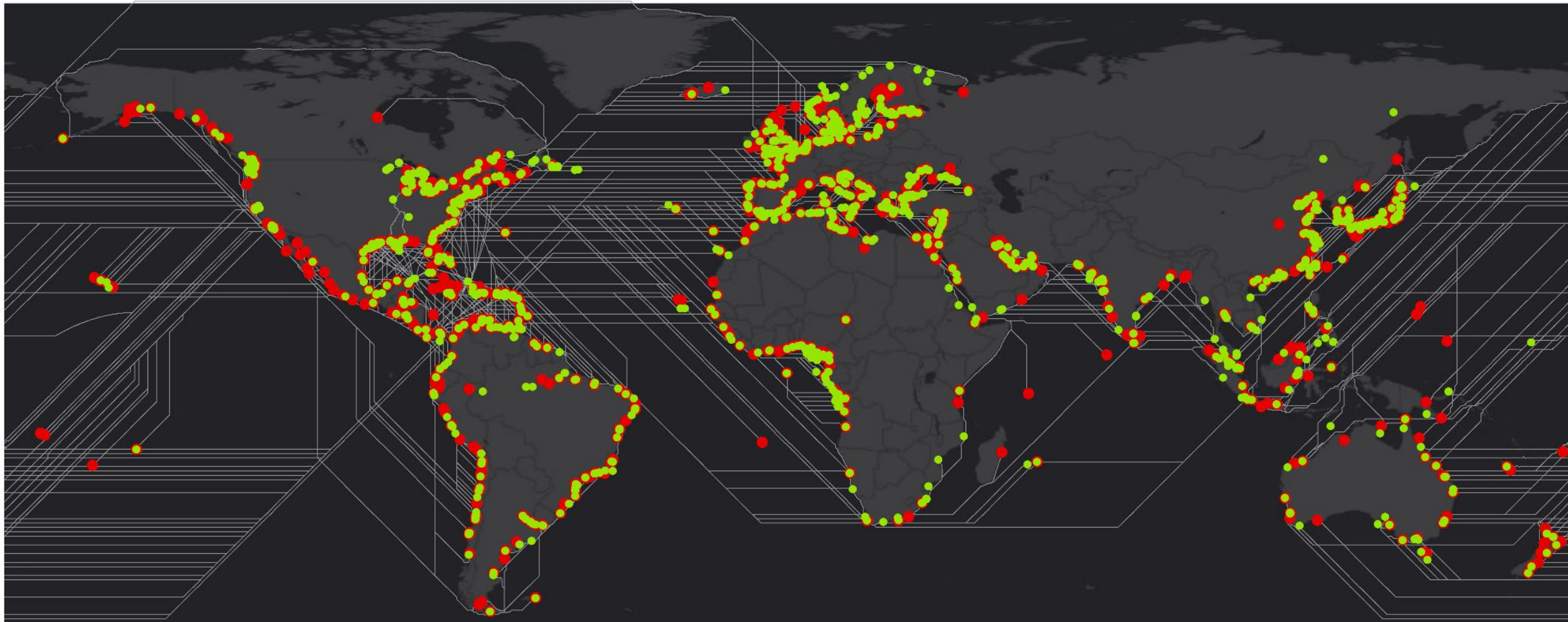
# GTAP Global Trade Model



# Application



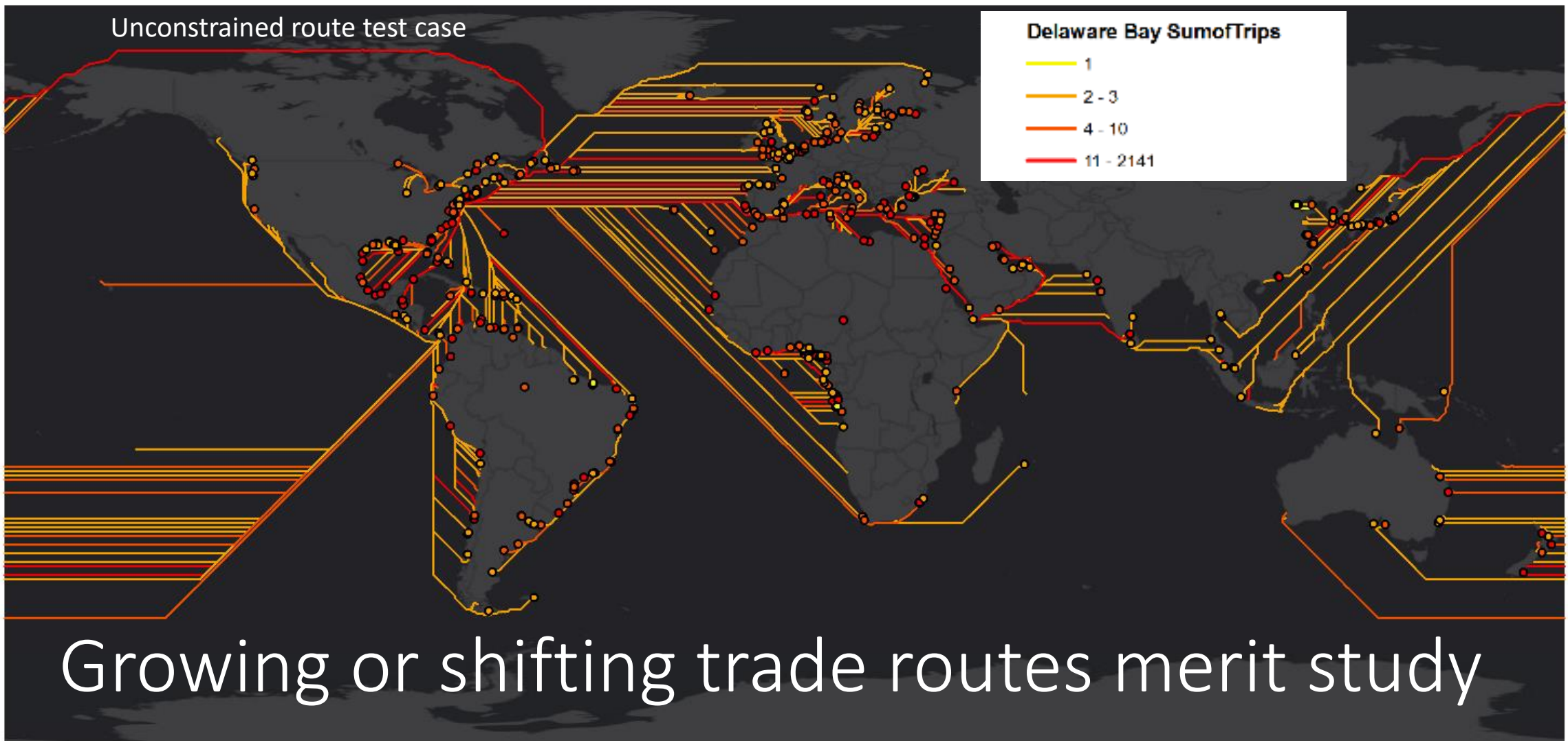
Origin-Destination Overlay



Growing or shifting trade routes merit study

**TPP risks identified: "... localized environmental impacts at selected U.S. ports..."**





**Legend**

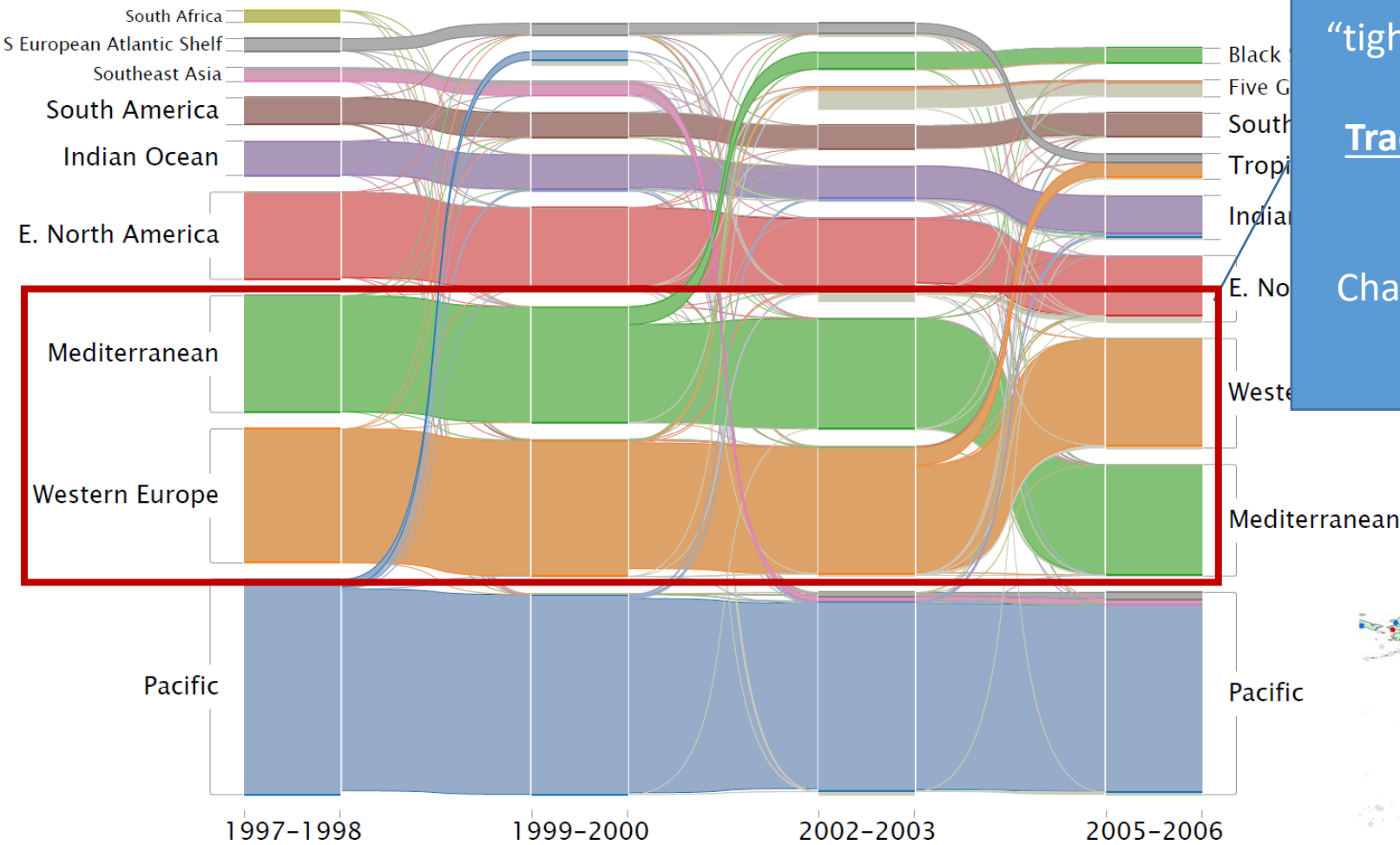
**Delaware Bay Sum of Trips**

- 1
- 2 - 3
- 4 - 10
- 11 - 2141

Example: Delaware Bay Port Pairs with other Global Gateways

# TPP risks identified: “... introduction of invasive species...”

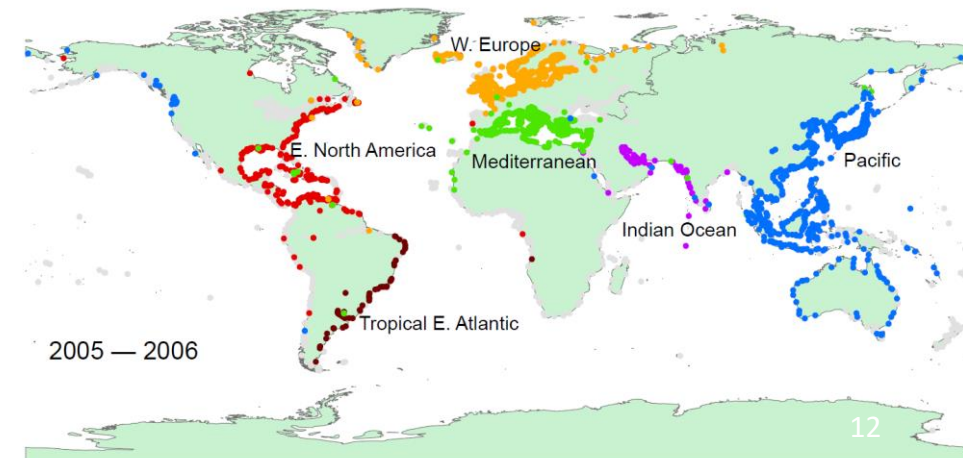
Six dominant clusters of SFN during 2005-2006.



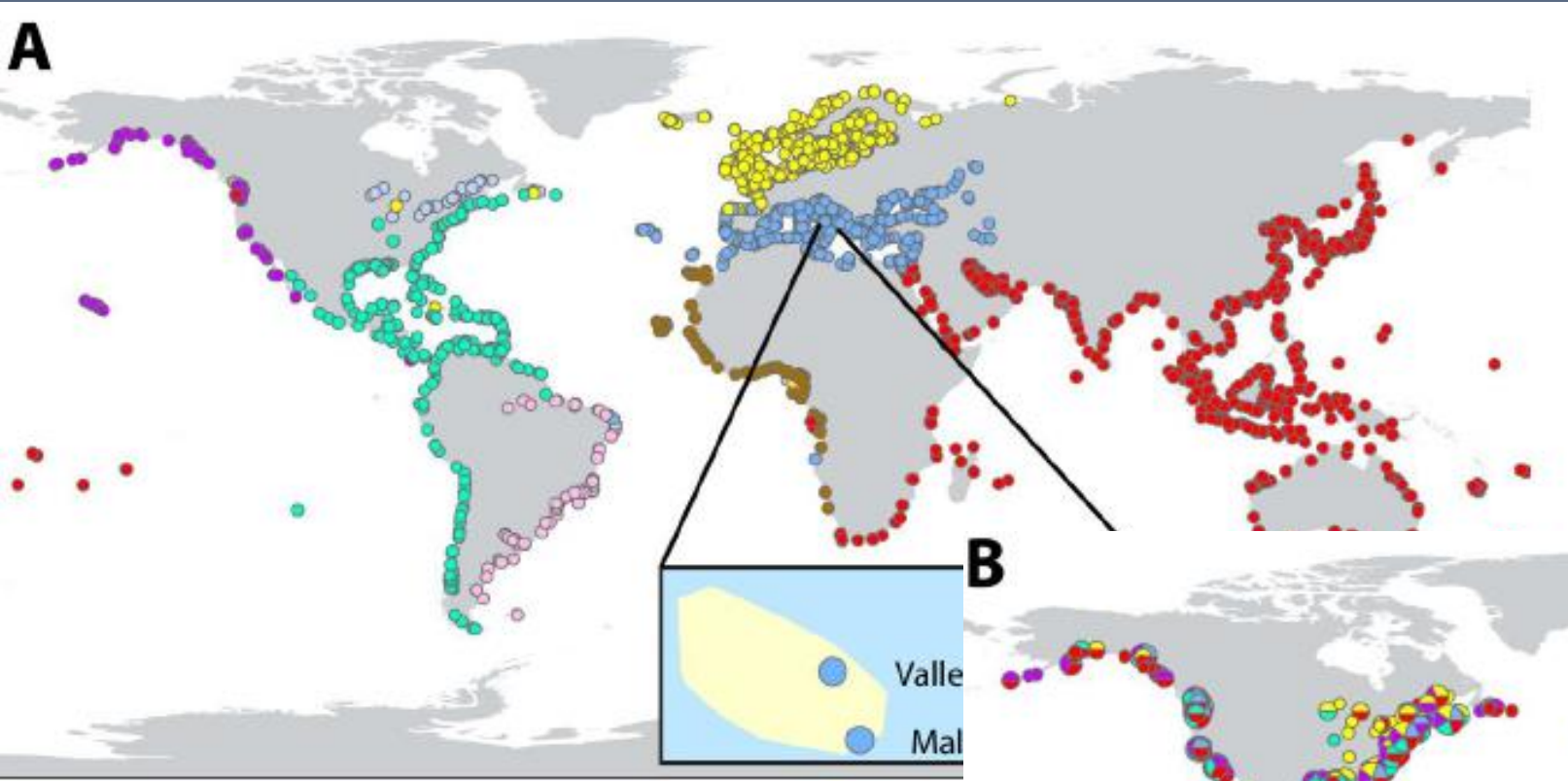
Clusters are groups of ports that are “tightly-coupled” due to species flows (NIS-RAPS)

Trade patterns, technology, vessel behavior, ..., evolve over time

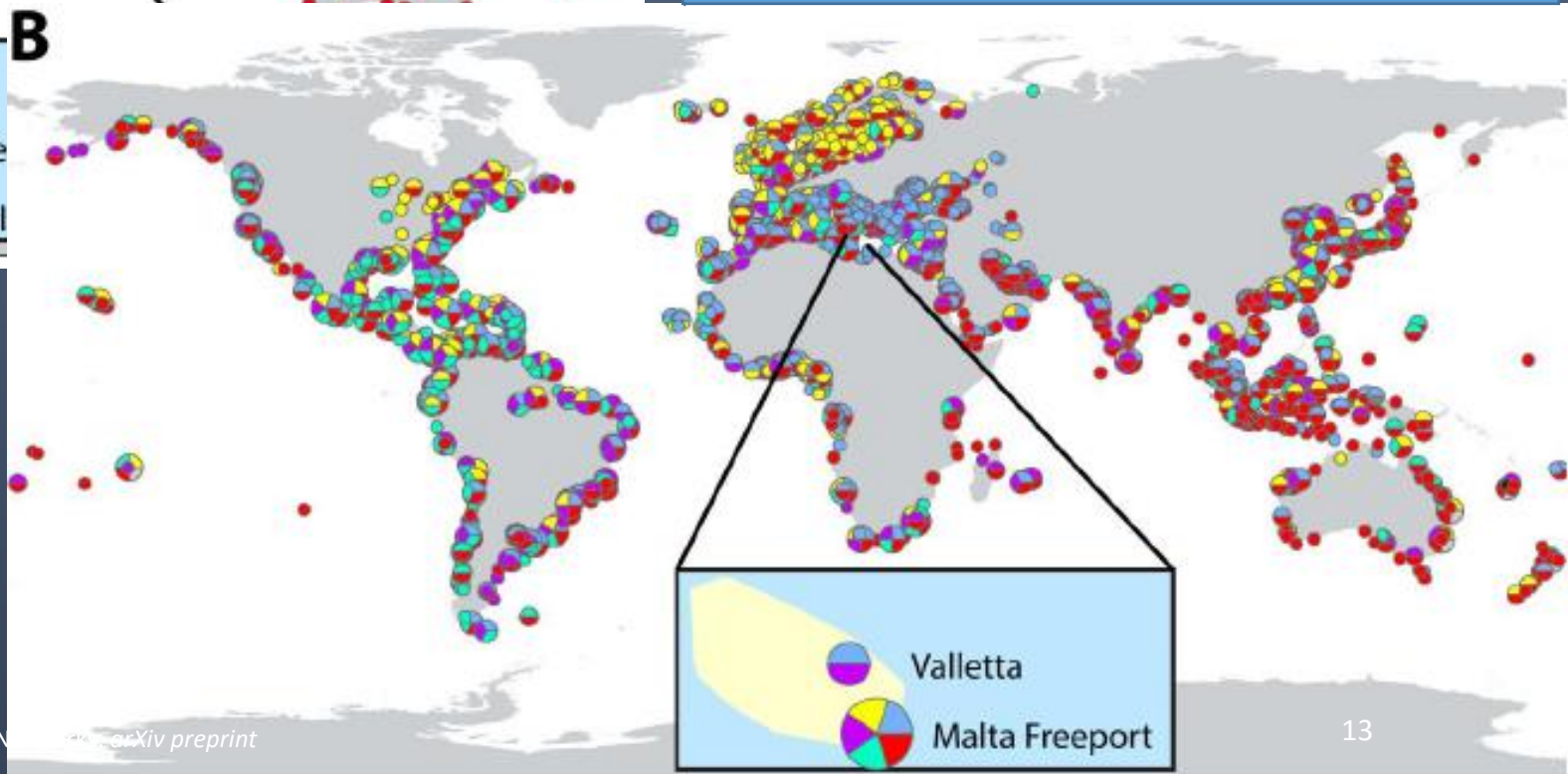
Changes in the species flow network modify the species flow risk of invasions.



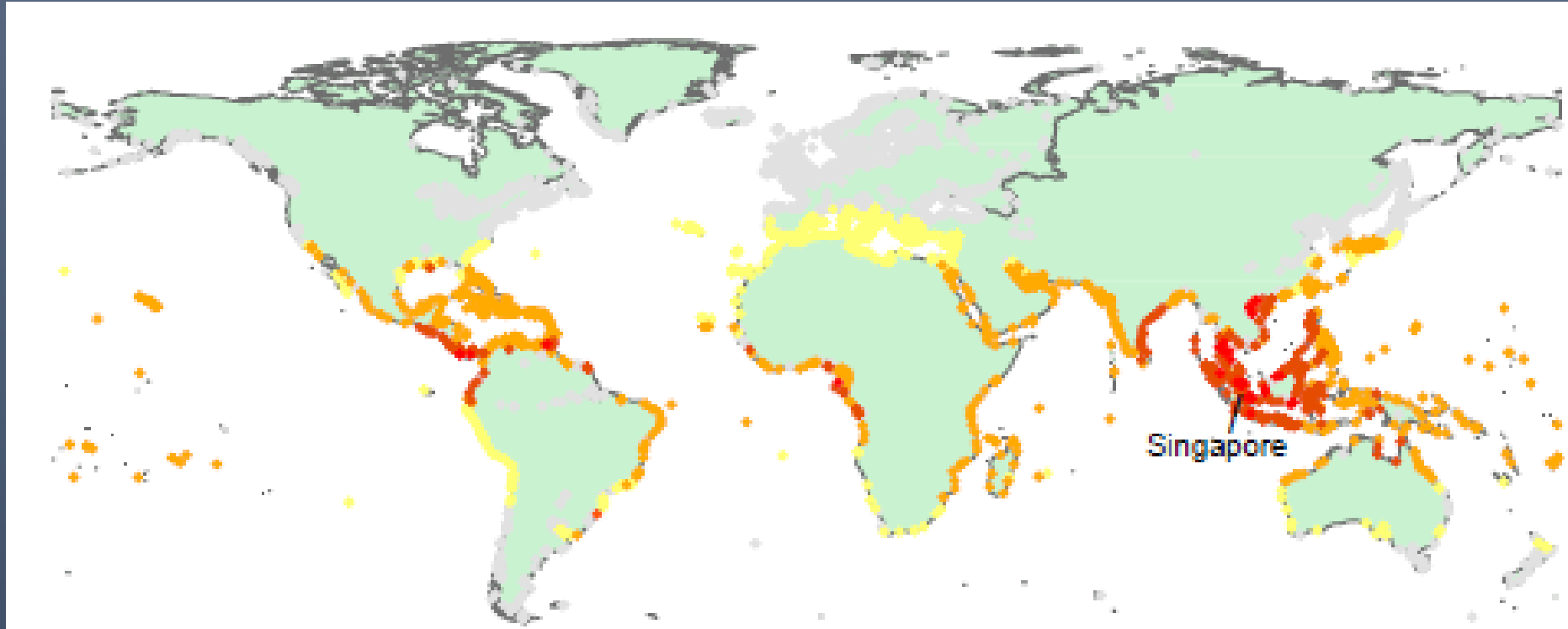
# TPP risks identified: "... introduction of invasive species..."



Higher-order networks can better capture complex ship movement patterns and yield overlapping clusters, highlighting ports that may be susceptible from different sources of invasions



# Risk of arrival and establishment of nondigenous species from Singapore



Ballast-invasive risk appears to be a positive function of:

- # voyages by given ship type
- mean ballast discharge by ship type
- different ecoregion
- environmental similarity (salinity, temp)

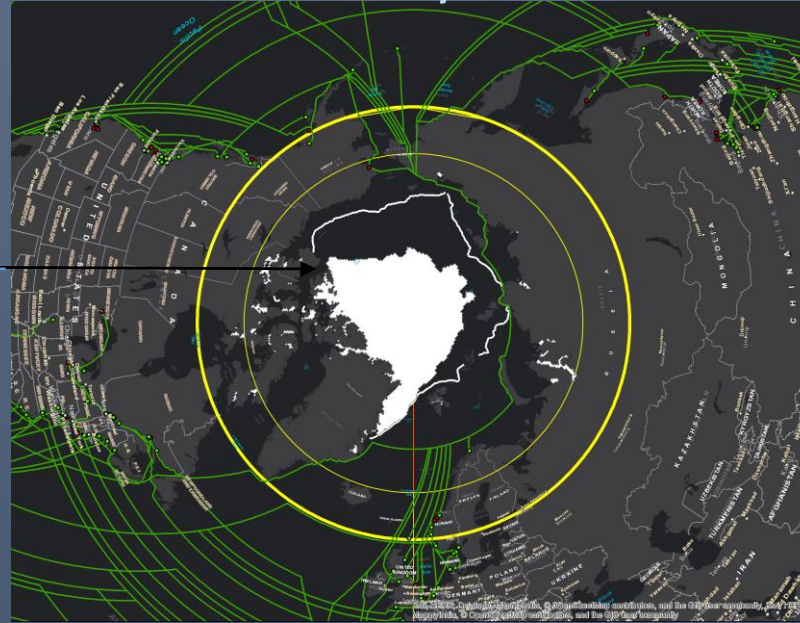
*(Xu et al. 2014)*

# Arctic case study design?

- Key nations in case study of opening sea ice:  
China, USA, Spain, Malaysia, Thailand, Indonesia, South Korea, Australia, Canada, Taiwan, Norway, Japan, Egypt, Italy, Denmark, Great Britain, 26 others
- Current status: very few current routes connecting through Arctic Ocean (quantify)
  - Case 1 (**Status quo**): Compute NIS connectivity risk for current observation(s)
  - Case 2 (**Arctic museum**): “turn the cross-Arctic routes off”
  - Case 3 (**Arctic frontier**): increase connectivity – maybe new trade, more trips

# Current Day Scenario

~1000 routes crossing Arctic



**Green:** "current day" routes  
Ave Distance: ~16.7k KM

**Orange:** "avoid Arctic" routes  
Ave Distance: ~18.3k KM

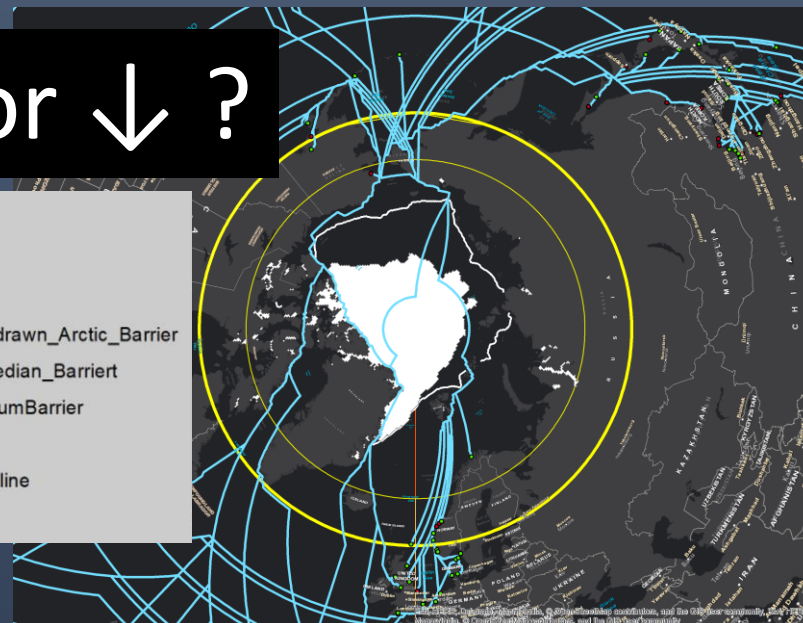
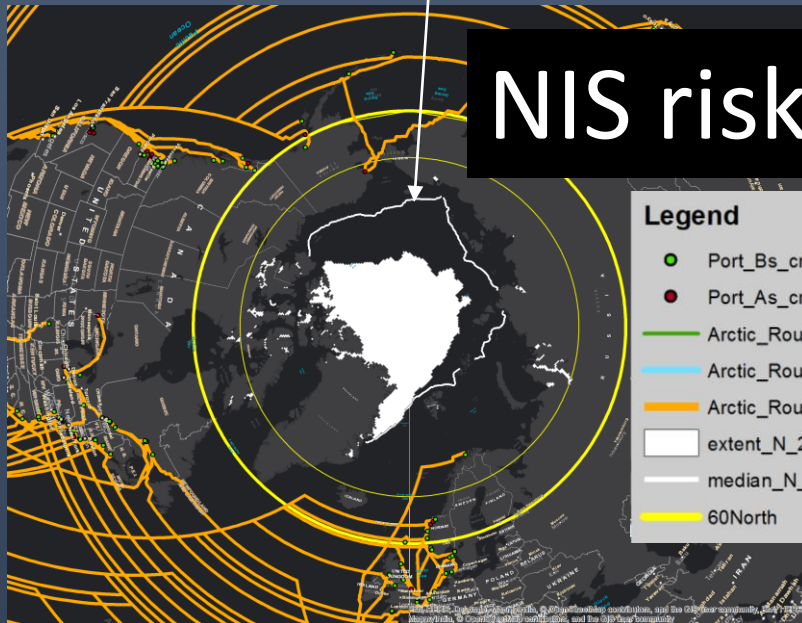
**Light blue:** "open Arctic"  
Ave Distance: ~17.2k KM

Ice sheet September 2012  
and Sept median 1981-2010

## Arctic Museum

## Arctic Throughway

NIS risk ↑ or ↓ ?



### Legend

- Port\_Bs\_cross\_arctic
- Port\_As\_cross\_arctic
- Arctic\_Routes\_with\_Jim\_spec\_drawn\_Arctic\_Barrier
- Arctic\_Routes\_NSIDC\_Sept\_Median\_Barrier
- Arctic\_Routes\_with\_ArcticMuseumBarrier
- extent\_N\_201209\_polygon
- median\_N\_09\_1981\_2010\_polyline
- 60North

# Thank you

Discussion welcome ...

... collaboration invited



James Corbett



Amanda Countryman



Erin Grey



David Lodge



Nitesh Chawla



Thanuka Wickramaratne